

MEMS SENSOR FOR BALANCE DISORDERS



● The lightweight MEMS sensor may someday act as a cue to patients with inner-ear disorders.

BMDO HISTORY

The Charles Stark Draper Laboratories (Cambridge, MA) developed a micromachining process for the manufacture of miniature inertial sensors using microelectromechanical systems (MEMS). The low-cost sensors combined the functions of a gyroscope and an accelerometer with an information processor to provide inertial guidance components for BMDO's

Lightweight Exoatmospheric Advanced Projectiles program. The lightweight sensors have numerous applications in military and commercial technology, including precision-guided munitions, autopilot controls, airbag deployment, and medical electronics. In this last category, the micromachining innovation may lead to a unique way to help patients with balance disorders.

HOW IT WORKS

Draper Labs' micromachining process uses controlled chemical etching that can place up to 10,000 devices on a single silicon chip. The chips can be mass-produced, keeping production costs to a minimum. In addition, the low power requirements, small size, and complexity of the chip make it a versatile component for a lightweight feedback system. The chip's features have lent themselves well to a collaborative project involving the restoration of balance cues to patients with inner-ear disturbances.

MEDICAL SIGNIFICANCE

Vestibular (inner-ear) disorder is an uncommon but sometimes very debilitating condition that can be caused by transient viral infections, tumors, or trauma to the vestibular organs and nerves. Signals about the body's orientation in space (particularly rotational changes) are processed by a system of hair cells that are moved about by fluid flow within the inner ear's semicircular canals. These signals are relayed by the vestibular nerves to the brain, which in turn signals the body to make postural adjustments to maintain balance. Damage to the

Vestibular disease can be detected by observing rhythmic movements of the eyes while instilling warm or cool water into the ears. In a normal subject, cool water causes the eyes to move in the opposite direction of the irrigated ear, and warm water causes movement toward it. The clinician can judge certain aspects of disease by watching how fast or how slowly the eye movements occur and whether movement is suppressed in a particular direction.

vestibular system can cause some patients to lose their sense of balance, resulting in recurrent dizziness that can greatly inhibit lifestyle and cause injury. In February 1997, researchers at Draper Labs, the Massachusetts Eye and Ear Infirmary (MEEI), and the Massachusetts Institute of Technology (MIT), with the support of the W. M. Keck Foundation of Los Angeles, began to consider the MEMS chip as a component in a feedback loop system that alerts patients when they begin to lose their balance. An initial system design would incorporate MEMS devices into a vest that can be comfortably worn by a patient. When one of the MEMS chips senses a deviation of a few degrees from vertical (indicating that the wearer is falling), a vibration is induced that alerts the wearer to correct the situation. An arrangement of chips can take the place of normal cues provided by the ailing vestibular system. Eventually, researchers hope that such an inertial guidance device could be inserted in the inner ear itself, much as cochlear implants are implanted in deaf patients.

VENTURES OR PRODUCT AVAILABILITY

This nascent work is part of the Balance Project in the W. M. Keck Neural Prosthesis Research Center at Massachusetts General Hospital. The center includes investigators from MIT, MEEI, and Draper Labs. The center's director is Donald Eddington, Ph.D., of the Cochlear Implant Research Laboratory at MEEI. Draper Labs is contributing internal funding to this project as well.

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